

Sampling and Analysis Plan (SAP)
Development for Surface Water Quality Monitoring and Related Activities

SOP Number: WQ-_____

Issuance Date: Feb -2010

Water Data Management & Environmental Quality
St. Louis District
U.S. Army Corps of Engineers



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This Standard Operating Procedure (SOP) provides guidance for the preparation of a Sampling and Analysis Plan (SAP) for the collection of surface water quality and related data. The goal of this SOP is to promote consistency in the generation and execution of SAPs and thus help generate surface water quality and related data of known quality for its intended purpose.

1.2 APPLICABILITY

This SOP applies to all surface water quality and related monitoring efforts implemented by the Water Quality Unit within the St. Louis District's Water Data Management & Environmental Quality Section.

1.3 FUNCTIONAL EQUIVALENCIES

SAPs are intended to integrate all the technical and quality aspects of a surface water quality or related monitoring project, including planning, implementation, and assessment. They serve as the work plan, field-sampling plan, and quality assurance project plan (QAPP) for a monitoring project to be implemented. A SAP will provide information and procedures regarding the following:

- project background
- data needs and usage
- data quality objectives
- data collection approaches
- laboratory requirements
- data management and assessment
- specific quality assurance (QA)
- quality control (QC) activities

SAPs prepared in accordance with this SOP are intended to meet all the requirements for a QAPP identified by the U.S. Environmental Protection Agency (USEPA).

1.4 SYSTEMATIC PLANNING PROCESS

To ensure that a data collection effort is properly designed, it is important that a systematic planning process (SPP) be utilized to develop data quality objectives (DQOs) for all data collection efforts. DQOs are qualitative and quantitative statements developed by data users that establish the uncertainty that can be tolerated by the user and still meet the user's need. DQOs clarify the objectives for data collection, define the most appropriate type of data to collect, determine the most appropriate conditions from which to collect data, and specify tolerable limits on decision errors which will be used as the basis for establishing the quantity and quality of data needed to support the decision. Establishment of DQOs involves the interaction of managers and technical staff in deciding what information is needed, why it is needed, how it will be used, how it will be collected, and any time/resource constraints affecting data collection. By involving everyone who plans to use the data, as well as the groups assigned to collect it, one can increase the likelihood that it will meet the needs of the user(s). The SPP is a concept, planning process and product for ensuring environmental data are of the type, quantity, and quality needed for making decisions. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for the project, and how many samples to collect. The outputs of the SPP should be clearly articulated in a SAP that details the data collection effort to be implemented.

1.5 GRADED APPROACH TO WATER QUALITY MONITORING

It is recognized that a “one size fits all” approach to surface water quality and related monitoring activities is not appropriate. Applying a graded approach to SAP development means that the level of detail in a SAP will depend on the specific objectives and data needs of the monitoring project. For example, the data quality expectations of a scoping or reconnaissance study are different from that of an intensive project-specific study because the purpose or intended use of the data is different. The specific application of the graded approach to the development of SAPs is described in Section 2.3.2.

2. SAP REQUIREMENTS

2.1 POLICY

All surface water quality and related monitoring activities implemented or overseen by the St. Louis District’s Environmental Quality Unit will have a SAP developed and approved prior to the collection or compilation of any data. The SAP will be developed using a systematic planning process based on a graded approach.

2.2 PURPOSE

The purpose of a SAP is to document planning results for surface water quality management and related data operations, and to provide a project-specific “blueprint” for obtaining the type and quality of environmental data needed for a specific decision or use. The SAP documents how QA and QC will be applied to the planned data collection operation to assure that the results obtained are of the type and quality needed and expected.

2.3 GENERAL CONTENT AND LEVEL OF DETAIL

2.3.1 General Content

The SAP should be composed of standardized, recognizable elements covering the entire project from planning through implementation, to assessment. Section 3 of this document describes specific elements that should be addressed in a SAP.

While most SAPs will describe project or task specific activities, there may be occasions when a generic SAP may be more appropriate. A generic SAP addresses the general, common activities of a program that are to be conducted at multiple locations or over a long period of time. For example, a generic SAP may be useful for a large monitoring program that uses the same methodology at different locations. A generic SAP describes, in a single document, the information that is not site or time-specific but applies throughout the program. Application-specific information is then added to the approved SAP as that information becomes known or completely defined. A generic SAP should be reviewed periodically to ensure that its content continues to be valid and applicable to the program over time.

2.3.2 Level of Detail

The level of detail of a SAP should be based on a graded approach. Therefore, the level of detail in each SAP will vary according to the nature of the work being performed and the intended use of the data. As a result, an acceptable SAP for some water quality data operations may only require a qualitative discussion of the data collection process and its objectives while others may require extensive documentation to adequately describe a complex monitoring project.

2.4 SAP PREPARATION AND APPROVAL

SAPs are to be prepared by the coordinator of the water quality or related monitoring project or program to be implemented. In accordance with the SPP process, all users of the data to be collected should be involved in the development of the SAP.

All SAPs need to be reviewed and approved by the appropriate reviewers to ensure that the SAP contains the appropriate content and level of detail. SAPs developed by the Environmental Quality Unit will be reviewed, at a minimum, by the following personnel: 1) Sampling Coordinator for the Environmental Quality Unit, 2) Team Leader of the Environmental Quality Unit, 3) representative of the analytical laboratory to be utilized, 4) representative of any cooperator involved in the data collection effort, and 5) Section Chief of the Water Data Management & Environmental Quality Section.

2.5 SAP IMPLEMENTATION

None of the data collection work addressed by the SAP should be started until the SAP has been approved and distributed to project personnel – except in situations requiring immediate action to protect human health and the environment. The project coordinator needs to ensure that the SAP is implemented as approved and that all personnel involved in the work have direct access to a current version of the SAP and all other necessary planning, implementation, and assessment documents. These personnel should understand the requirements of the SAP prior to the start of data generation activities.

2.6 SAP REVISION

Although the approved SAP must be implemented as prescribed, it is a living document that will be adaptively managed based on field conditions. Because of the complex and diverse nature of water quality and related data operations, changes to original plans are often needed. When such changes occur, the Water Quality Unit Team Leader will determine if the change significantly impacts the technical and quality objectives of the project. When a substantive change is warranted, the project coordinator will need to modify the SAP to document the change and submit the revision for approval by the same authorities that performed the original review. Only after the revision has been received and approved (at least verbally with written follow-up) by project personnel, will the change be implemented.

For programs or projects of long duration, such as multi-year monitoring programs or projects using a generic SAP, the SAP needs to be reviewed at least annually by the Project Coordinator. When revisions are necessary, the SAP must be revised and resubmitted for review and approval.

3. SAP ELEMENTS

3.1 CONTENT REQUIREMENTS

A SAP is a formal document describing in comprehensive detail the necessary QA, QC, and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. The SAP needs to provide sufficient detail to demonstrate that the:

- project's technical and quality objectives are identified and agreed upon;
- intended measurements, data generation, or data acquisition methods are appropriate for achieving the project's objectives; and
- data quality review procedures are sufficient for confirming data quality and identifying any limitations on the use of the data.

Water quality data collection efforts may require the coordinated efforts of many individuals, including managers, engineers, scientists, statisticians, and others. The SAP must integrate the contributions and requirements of everyone involved into a clear, concise statement of what is to be accomplished, how it will be done, and by whom. It must provide understandable instructions to those who must implement the SAP, such as field sampling personnel, the analytical laboratory, data reviewers, and data analysts.

In order to be effective, the SAP must specify the level or degree of QA and QC activities needed for the particular water quality or related data operations. Because this will vary according to the purpose and type of work being done, a graded approach should be used in planning the work. This means that the QA and QC activities applied to a monitoring project will be commensurate with the:

- purpose of the water quality data operation (e.g., scoping study, ambient assessment, problem quantification, research and development, evaluate implemented remedial actions, etc.),
- type of work to be done (e.g., ambient monitoring, source monitoring, site characterization, etc.), and
- intended use of the results (e.g., annual report, project-specific report, selection of remedial technology, etc.)

The SAP should be composed of standardized, recognizable elements covering the entire project from planning to final report preparation. The elements of a SAP should be grouped into five general parts:

- **Document Control Information** – This forward section includes a title and approval sheet, table of contents, and a distribution list for the SAP.
- **Section I: Project Description** – This section describes the background, goals, and objectives of the project as well as the roles and responsibilities of project participants. The elements within this section ensure that the project has a defined goal, that participants understand the goal and approach to be used, and that the DQOs have been defined and documented.
- **Section II: Data Collection Approach** – This section addresses all aspects of project design and implementation. Elements within this section ensure that appropriate

methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and are properly documented.

- **Section III: Data Management and Analysis** – This section addresses all aspects of data reduction, storage, and analysis. Elements within this section ensure that only data of known quality is entered into the data management system. Elements within this section also described how data are to be analyzed and interpreted.
- **Section IV: Data Quality Review** – The data quality review elements address the activities for assessing the effectiveness of the implementation of the project and associated QA and QC activities. The purpose of data quality assessment is to ensure that the SAP is implemented as prescribed and data quality is within control limits.

All applicable elements, including the content and level of detail under each element, must be addressed in the SAP. If an element is not applicable, state this in the SAP. Documentation, such as an approved Work Plan, Standard Operating Procedures, etc., may be referenced in response to a particular required SAP element to reduce the size of the SAP. Current versions of all required reference documents must be attached to the SAP itself or readily available to persons implementing the SAP.

3.2 DOCUMENT CONTROL INFORMATION

This forward section includes a title and approval page, table of contents, and a distribution list for the SAP.

3.2.1 Title and Approval Sheet

On the Title and Approval Sheet, include the title of the project; project number; the name of the organization(s) implementing the project; the effective date of the project; and the names, titles, signatures, and approval dates of appropriate approving officials. At a minimum, the following signatures should be on the Title and Approval Sheet:

- Project Coordinator
- Sampling Coordinator
- Water Quality Team Leader
- Analytical Laboratory Representative
- Water Control and Water Quality Section Chief (Designated QA Officer)

3.2.2 Table of Contents

Provide a table of contents for the document, including, figures, tables, and appendices.

3.2.3 Distribution List

List the individuals who need copies of the approved SAP and any subsequent revisions, including all persons responsible for implementation. Paper copies need not be provided to individuals if equivalent electronic information systems can be used.

3.3 SECTION I: PROJECT DESCRIPTION

The elements in this section describe the project in terms of its history, objectives, management, roles and responsibilities of the participants, etc. These elements document that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planning outputs have been documented.

3.3.1 Project/Task Organization and Responsibilities

Identify the individuals or organizations participating in the project and discuss their specific roles and responsibilities. Provide a concise organization chart showing the relationships and the lines of communication among all project participants. Include other data users who are outside of the organization generating the data, but for whom the data are nevertheless intended. The organization chart must also identify any subcontractor relationships relevant to environmental data operations, including laboratories providing analytical services. The following is a list of key activities that require the identification of a responsible person.

- Overall Project Coordination
- Sampling Operations
- Sampling Quality Control
- Laboratory Analysis
- Laboratory Quality Control
- Data Processing
- Data Processing Quality Control
- Data Quality Review
- Data Analysis
- Data Analysis Quality Control
- Data Reporting
- Overall Project Quality Assurance

3.3.2 Background Information

State the specific water quality or related concern to be addressed and the desired outcome to be achieved. Include sufficient background information to provide a historical and scientific perspective for the monitoring project.

3.3.3 Data Quality Objectives

List the data quality objectives (DQOs) for the monitoring project. The DQOs should be defined in accordance with SOP Number WQ- “Establishing Data Quality Objectives”.

3.3.4 Project/Task Description

Provide a summary of all work to be performed, products to be produced, and the schedule for implementation. Provide maps or tables that show or state the geographic locations of field tasks. This discussion need not be lengthy or overly detailed, but should give an overall picture of how the monitoring will address the project’s DQOs.

3.3.5 Documents and Records

Describe the process and responsibilities for ensuring the appropriate project personnel have the most current approved version of the SAP.

Itemize the information and records that must be included in the data report package and specify the reporting format for hard copy and any electronic forms. Records can include raw data, data from other sources such as data bases or literature, field logs, sample preparation and analysis logs, instrument print outs, model input and output files, and results of calibration and QC checks.

Identify any other records and documents applicable to the project that will be produced, such as interim progress reports and final reports. Specify the level of detail of the field

sampling, laboratory analysis, literature or data base collection, or modeling documents or records needed to provide a complete description of any difficulties encountered.

Specify or reference all applicable requirements for the final disposition of records and documents, including location and length of retention period.

3.4 SECTION II: DATA COLLECTION APPROACH

The elements in this section address all aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and documented. The tasks described in these elements should have been summarized in Section I: Project/Task Organization. The purpose here is to provide detailed information of the methods that will be used. If the methods are well documented and are readily available to all project participants, citations are adequate; otherwise, detailed copies of the methods and/or SOPs must accompany the SAP either in the text or as attachments.

3.4.1 Data Collection Design

Describe the data collection design for the project. This should include, as appropriate, the following:

- the design and rationale of the sampling network,
- the sampling locations,
- sampling frequency,
- the types and numbers of samples required, and
- parameters to be measured or analyzed.

3.4.2 Sampling Methods

Describe the procedures for collecting samples. Identify the sampling methods and equipment, sample preservation requirements, decontamination procedures, and any special sampling needs. If a method allows the user to select from various options, then the method citations should state exactly which options are being selected. Describe specific performance requirements for the method (e.g., detection and reporting limits, etc.).

Describe the process for the preparation and decontamination of sampling equipment; the selection and preparation of sample containers, sample volumes, and preservation methods; and maximum holding times to sample extraction and/or analysis.

3.4.3 Sample Handling, Custody, and Shipment

Describe the requirements for sample handling and custody in the field, laboratory, and transport, taking into account the nature of the samples, the maximum allowable sample holding times before extraction or analysis, and available shipping options and schedules. Sample handling includes packaging, shipment from the site, and storage at the laboratory. Examples of sample labels, analytical request forms, and any sample custody logs should be included.

3.4.4 Analytical Methods

Identify the methods that will be used by the laboratory to analyze the collected samples for the identified parameters (method numbers should be given where appropriate). If a method allows the user to select from various options, then the method citations should state exactly which options are being selected. Specify the laboratory turnaround time needed, if important to

the project schedule.

3.4.5 Quality Control

Identify QC activities needed for each sampling, analysis, or measurement technique. For each required QC activity, list the associated method or procedure, acceptance criteria, and corrective action. QC activities for the field and laboratory include, but are not limited to, the use of blanks, duplicates, matrix spikes, laboratory control samples, surrogates, or second column confirmation. State the frequency of analysis for each type of QC activity, and the spike compounds sources and levels. State or reference the required control limits for each QC activity and corrective action required when control limits are exceeded and how the effectiveness of the corrective action will be determined and documented.

Measurement quality objectives (MQO) should be established for data quality indicators (DQI) appropriate to the project. DQIs are measurable attributes for the attainment of the necessary quality to support the project's DQOs. DQIs include precision, bias (accuracy), completeness, representativeness, comparability, reproducibility, sensitivity, and statistical confidence. Describe or reference the procedures to be used to calculate applicable statistics for DQIs (e.g., relative percent difference, relative standard deviation or coefficient of variation, percent recovery, etc.). Copies of the formulas are acceptable as long as the accompanying narrative or explanation specifies clearly how the calculations will address potentially difficult situations such as missing data values, "less than" or "greater than" values, and other common data qualifiers. The laboratory's QA/QC protocol for assuring analytical results should be summarized and referenced.

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3.4.6 Instrument/Equipment Calibration and Maintenance

Identify all instruments and equipment used for data generation or collection that need calibration and maintenance to maintain their performance within specified limits. Describe or reference how calibration will be conducted. As appropriate, certified equipment and/or standards with known valid relationships to recognized performance standards should be used. Identify instruments and equipment that require periodic preventive and corrective maintenance and describe or reference how maintenance will be performed. Discuss how the availability of critical spare parts will be assured and maintained. Indicate how records of calibration and maintenance will be documented and linked to the appropriate instruments and equipment.

3.4.7 Inspection/Acceptance of Supplies and Consumables

Describe how supplies and consumables (e.g., standard materials and solutions, sample bottles, reagents, deionized water, Preservatives, electronic data storage media) will be inspected and accepted for use by the project. State acceptance criteria for such supplies and consumables.

3.4.8 Non-direct Measurements

Identify any types of data needed for project implementation or decision making that are obtained from non-measurement sources such as computer data bases, programs, literature files, and historical data bases. Describe the intended use of the data. Define the acceptance criteria for the use of such data in the project and specify any limitations on the use of the data.

3.5 SECTION III: DATA MANAGEMENT AND ANALYSIS

The elements of this section describe how collected data will be managed and how the

data will be analyzed for project purposes.

3.5.1 Data Management

Describe the data management process for the project, tracing the path of the data from their generation to their final use or storage (e.g., the field, the office, the laboratory). Describe or reference the standard record-keeping procedures, document control system, and the approach used for data storage and retrieval on electronic media. Discuss the control mechanism for detecting and correcting errors and for preventing loss of data during data reduction, data reporting, and data entry to forms, reports, and databases. Provide examples of any forms or checklists to be used.

3.5.2 Data Analysis

Describe how the data will be analyzed to meet the purposes of the project. Identify all statistical methods that will be used to analyze the data (e.g., preliminary data analysis, descriptive statistics, comparative statistics, hypothesis testing, trend analysis, etc.). If possible, identify the specific statistical tests that will be used and any predetermined sample type or completeness requirements (e.g., number of samples, paired samples, etc.). If spatial analysis is going to be employed, describe how the collected data will be geo-referenced and any accuracy requirements. Describe any models that will be utilized and supported by any collected data. Identify the specific inputs that are needed to calibrate, validate, and run the model to address any uncertainty concerns with the model. Identify any computer software that will be used or needed for data analysis.

3.6 SECTION IV: DATA QUALITY REVIEW

The elements of this section describe how data quality review, specifically data verification and validation, will be implemented in an objective and consistent manner. Data verification and validation is the confirmation by examination and objective evidence that specific requirements of the SAP and intended use of the data have been fulfilled. Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. Data validation is an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (verification) to determine the analytical quality of a specific data set.

3.6.1 Data Verification and Validation Methods

Describe the process to be used for verifying data collection and validating the collected data set. Precisely define and interpret how verification and validation issues differ for the project. Provide examples of any forms or checklists to be used. Identify any project-specific calculations required. Discuss how issues will be resolved and how findings will be conveyed to data users.

3.6.2 Reconciliation with SAP Requirements

Describe how the results obtained from the project will be reconciled with the requirements defined by the SAP. Outline any proposed methods to analyze the data and determine possible anomalies or departures from assumptions established in the SAP. Describe how reconciliation with user requirements will be documented, issues will be resolved, and how limitations on the use of the data will be reported to data users.

4. REFERENCES

- **Army Corps of Engineers. 2001.** Requirements for the preparation of sampling and analysis plans. Engineer Manual 200-1-3. Department of the Army, U.S. Army Corps of Engineers, Washington, DC.
- **Environmental Protection Agency 2001.** EPA Requirements for Quality Assurance Project Plans
- **EPA QA/R-5. EPA/240/B-01/003.** U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

5. APPENDICES

5.1 APPENDIX 1. SAP OUTLINE

Title and Approval Sheet

- Project name.
- Project number.
- Name of the organization implementing the project.
- The effective date of the project.
- Approvals – Names, titles, signatures, approval date.

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Distribution List

- List individuals and their organization.

PROJECT DESCRIPTION

1) Project/Task Organization and Responsibilities

- List key activities and the persons responsible for implementing the activity.
- Provide a concise organization chart showing relationships of project participants.

2) Background Information

- Identify any water quality concerns or problems.
- Identify the desired outcome to be achieved.
- Provide historical and scientific perspective for the monitoring project.
- Provide general map of project area.

3) Data Quality Objectives

- List the data quality objectives (DQOs) for the monitoring project.

4) Project/Task Description

- List tasks and give a schedule for their implementation.
- Explain how the collected data will address the project's DQOs.

5) Documents and Records

- Describe how the SAP will be distributed.
- Identify any reports that need to be prepared as part of the project (i.e., interim progress reports, final report) and the report format.
- Identify any requirements for disposition of records or documents.

II. DATA COLLECTION APPROACH

1) Data Collection Design

- a) Design and rationale of sampling network.
- b) Sampling locations.
- c) Sampling frequency.
- d) Types and number of samples required.
- e) Parameters to be measured and analyzed.

2) Sampling Methods

- a) Measurement methods and sample collection procedures.
- b) Preservatives and holding times for collected samples.
- c) Specific performance requirements (i.e., detection and reporting limits).

3) Sample Handling, Custody, and Shipment

- a) Sample handling and custody requirements.
- b) Shipment of samples.
- c) Example sample labels and analytical request forms.

4) Analytical Methods

- Include the following in tabular format: parameters, method numbers, detection limits, and reporting limits.
- Specify laboratory turnaround time needed.

5) Quality Control a) QC activities and frequency of analysis.

- Field measurements (i.e., field verification).
 - Sample collection (i.e., field blanks, equipment blanks, collocated samples (duplicates)).
 - Laboratory analysis (summarize and reference laboratory QA/QC protocol).
- b) Measurement quality objectives (MBOs).
- Define data quality indicators (DQIs) and how they will be assessed – give equations to calculate applicable statistics.
 - State the control limits or acceptance criteria for the defined DQIs.

6) Instrument/Equipment Calibration and Maintenance

- Identify all instruments and equipment that need calibration and maintenance to maintain their performance within specified limits.
- Describe how calibration will be done.
- Describe how maintenance will be performed and the availability of critical spare parts assured.

7) Inspection/Acceptance of Supplies and Consumables.

- Describe how supplies and consumables will be inspected and accepted for project use.

8) Non-direct Measurements

- Define any types of data needed for project implementation that are obtained from non-measurement sources.
- Define the acceptance criteria for the use of non-direct measurement data.

III. DATA MANAGEMENT AND ANALYSIS

1) Data Management a) Data management process.

- Describe the data management process for the project, tracing the path of the data from their generation to their final storage.

- b) Data entry QC.

- Discuss the control mechanism for detecting and correcting errors and for preventing loss of data during data reduction and data entry.
- Provide examples of any forms or checklists to be used.

2) Data Analysis

- Describe how the data will be analyzed to meet project purposes.
- Identify statistical methods and tests to be used.
- Describe any spatial analysis or modeling proposed and how it will be done.

IV. DATA QUALITY REVIEW

1) Data Verification and Validation Methods

- Describe the process to be used for verifying data collection and validating the collected data set.
- Provide examples of checklists to be used.
- Identify any project-specific calculations required.
- Discuss how issues will be resolved and findings conveyed to data users.

2) Reconciliation with SAP Requirements

- Describe how the results obtained from the project will be reconciled with the requirements defined by the SAP.